Unsaturated Zone
UZ IG
Interest Group

March 2015
Issue 18

The semi-annual Unsaturated Zone Interest Group (UZIG) newsletter highlights current topics concerning the unsaturated zone. Its purpose is to enhance communication within UZIG. It is not an official publication and should not be cited. Please contact authors or members of the newsletter committee with any questions, comments, and/or suggestions. Send desired changes in the mailing list to jtrost@usgs.gov.

Visit the website
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A multi-depth temperature probe for investigating subsurface heat transport

By Ramon Naranjo
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Temperature measurements are important for understanding hydrological and ecological processes in soils and stream channels. Measuring vertical temperature profiles is costly and difficult. Traditional approaches require external data loggers and battery supplies. As of 2011, no self-contained tool for temperature profiling could be located on the market. To address this need, the U.S. Geological Survey Nevada Water Science Center worked with company Alpha Mach (www.alphamach.com) to develop a novel temperature probe that was durable, inexpensive, and capable of long-term deployment with no need for probe removal to obtain data.

The probe has six autonomous temperature sensors (Maxim, Inc. Ibuttons, each with internal storage and battery) that are connected in series inside a ¾-inch schedule 80 PVC pipe (Fig.1). Temperature sensors are located at depths of 0, 0.10, 0.20, 0.50, 0.75 and 1.0 m.

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Fig. 1: One-meter long temperature probes with and without integral communication cable. Data are stored in individual embedded sensors and can be retrieved through the cable (left probe) or through a handheld reader making temporary contact with electrodes on the head of the probe. Both probes can be downloaded while submerged in water.

Banner photo (top): Soil profile beneath a stormwater infiltration basin in north-central Florida prior to emplacement of an engineered soil amendment to mitigate nutrient leaching (partially excavated suction lysimeter in foreground). *Photo by Andy O'Reilly, University of Mississippi.*

Submit a photo to uzig.news@gmail.com to be featured in the newsletter.

A multi-depth temperature probe for investigating subsurface heat transport

By Ramon Naranjo
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Article continued from front page.

Three types of Ibuttons sensors can be installed in the probe: Type G (General Use), Type Z (high resolution) and Type 22L (high precision). The Type Z used in test probes has a manufacturer-specified accuracy and precision of ±1.0 ºC and ±0.125 ºC, respectively. Calibration of probe-installed Type Z sensors using a circulating water bath and NIST-certified thermometer improved accuracy from ±1.0 °C to ±0.1 °C.

Probes are waterproof and can be downloaded under water. The low profile design avoids damage from floating debris and reduces visibility and vandalism (Fig. 2). Individual temperature sensors can be easily replaced when batteries weaken at a cost of $18 (Type Z). Data are retrieved by downloading through an integral cable or by using a hand-held reader pressed against two electrodes in the head of the probe (Fig. 1). Software developed for the probe allows for setting the frequency of observations, adjusting individual calibrations, and retrieving data. Following calibration, probes were successfully deployed over two irrigation seasons in the Walker River Basin, north-central Nevada, to study seepage losses (Fig 2).

Because probes are inexpensive, versatile, and robust they are likely to be useful in many environmental applications. Vertical temperature profiles can be logged autonomously for periods of up to several months in environments that are difficult to access or require minimal disturbance. The replaceable sensors extend the life of the probe. Probes provide continuous measurements to a depth of 1 m in streambeds for investigations of hyporheic flows, groundwater discharge and recharge dynamics, and ecologically relevant thermal regimes. The U.S. Geological Survey and Alpha Mach filed a joint U.S. Patent application for the probe and have entered into a license agreement to make the probes commercially available.

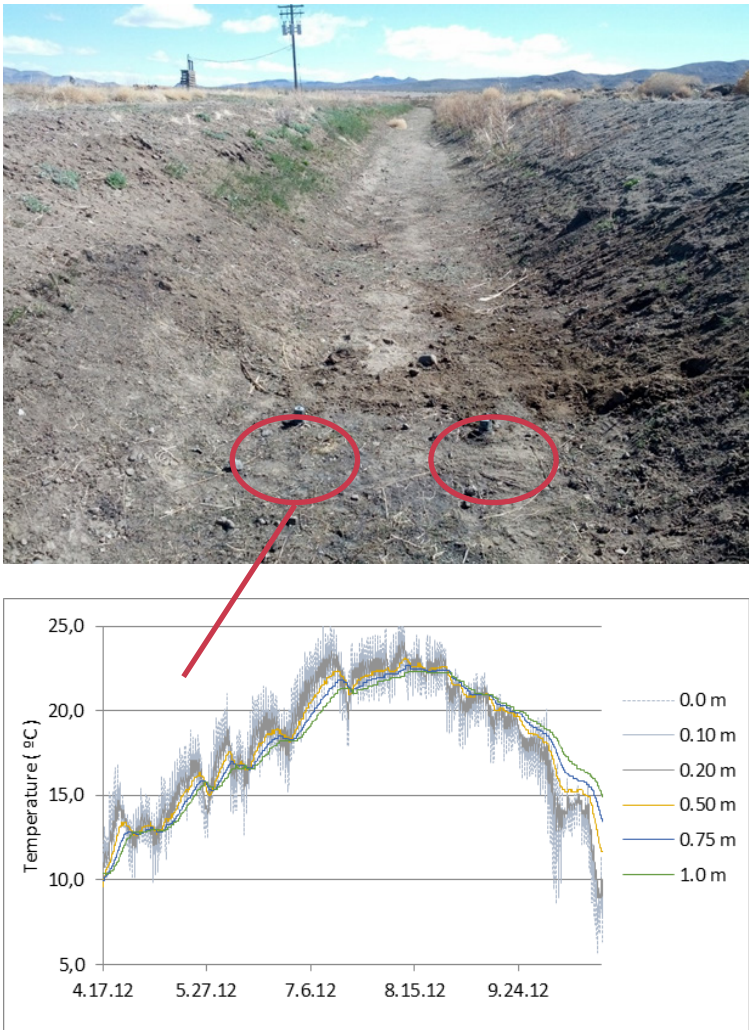

Fig. 2: (Photo) Two temperature probes installed in an irrigation canal in Smith Valley (Walker River Basin, north-central Nevada). Temperature probes have a low profile to avoid damage from debris and reduce visibility. Communication cables were buried to allow data retrieval from the right bank. (Graph) Temperatures of canal sediments with depth during the 2012 irrigation period.

Performance evaluation of hydrological models:

Statistical significance for reducing subjectivity in goodness-of-fit assessments

By Rafael Muñoz-Carpena and Axel Ritter
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Accompanying article published in *J. of Hydrology* 480(1):33-45. doi:10.1016/j.jhydrol.2012.12.004

Success in the use of computer models for simulating environmental variables and processes requires objective model calibration and verification procedures. Several methods for quantifying the goodness-of-fit of observations against model-calculated values have been proposed but none of them is free of limitations and are often ambiguous. When a single indicator is used it may lead to incorrect verification of the model. Instead, a combination of graphical results, absolute value error statistics (i.e. root mean square error), and normalized goodness-of-fit statistics (i.e. Nash–Sutcliffe Efficiency coefficient, *Ceff* or NSE) is currently recommended. Interpretation of *Ceff* values is often subjective, and may be biased by the magnitude and number of data points, data outliers and repeated data. The statistical significance of the performance statistics is an aspect generally ignored that helps in reducing subjectivity in the proper interpretation of the model performance.

In this work, approximated probability distributions for two common indicators (*Ceff* and root mean square error) are derived with bootstrapping (block bootstrapping when dealing with time series), followed by bias corrected and accelerated calculation of confidence intervals. Hypothesis testing of the indicators exceeding threshold values is proposed in a unified framework for statistically accepting or rejecting the model performance (Fig. 1).

It is illustrated how model performance is not linearly related with *Ceff*, which is critical for its proper interpretation (Fig. 2), so relatively small *Ceff* increases above 0.65 result in large model error reductions. Additionally, the sensitivity of the indicators to model bias, outliers and repeated data is evaluated. The potential of the difference between root mean square error and mean absolute error for detecting outliers is explored, showing that this may be considered a necessary but not a sufficient condition of outlier presence.

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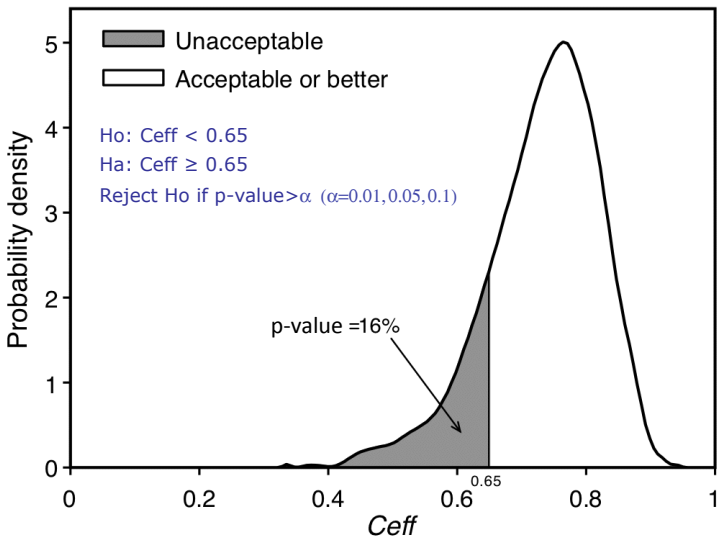

Figure 1. Hypothesis testing for model acceptance based on underlying distribution of the goodness of fit indicator (*Ceff*).

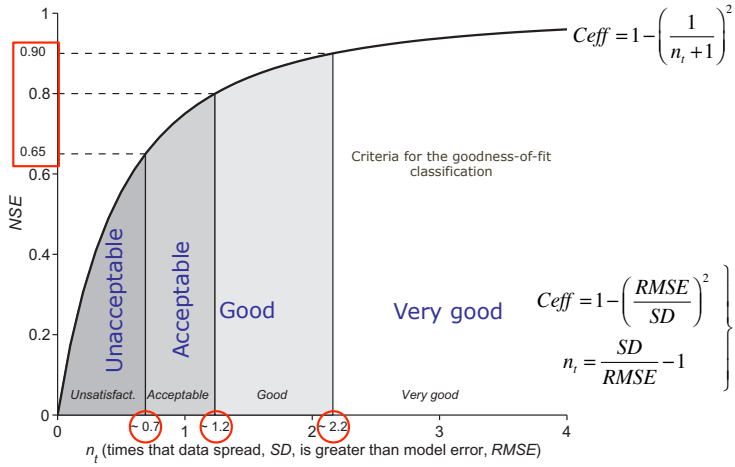

Figure 2. Interpretation of the Nash and Sutcliffe coefficient of efficiency and non linear relationship with model error.

Performance evaluation of hydrological models:

Statistical significance for reducing subjectivity in goodness-of-fit assessments

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The usefulness of the approach for the evaluation of model performance is illustrated with case studies including those with similar goodness-of-fit indicators but distinct statistical interpretation, and others to analyze the effects of outliers, model bias and repeated data. This work does not intend to dictate rules on model goodness-of-fit assessment. It aims to provide modelers with improved, less subjective and practical model evaluation guidance and tools.

A public domain software tool FITEVAL (Fig. 3) was developed (available http://abe.ufl.edu/carpena/software/FITEVAL.shtml) to simplify the analysis of observed vs. predicted data. The tool produces a compact graphical interpretation of the evaluation results including 1:1 line and series comparison, probability distribution of the approximated Nash and Sutcliffe coefficient of efficiency, p-value for hypothesis testing, identification of outliers and bias. New work is underway to incorporate the effects of observed data and model simulation uncertainties on the model performance analysis, and to develop a user-friendly FITEVAL web application for the analysis (available in the Fall). For questions, please contact the authors.

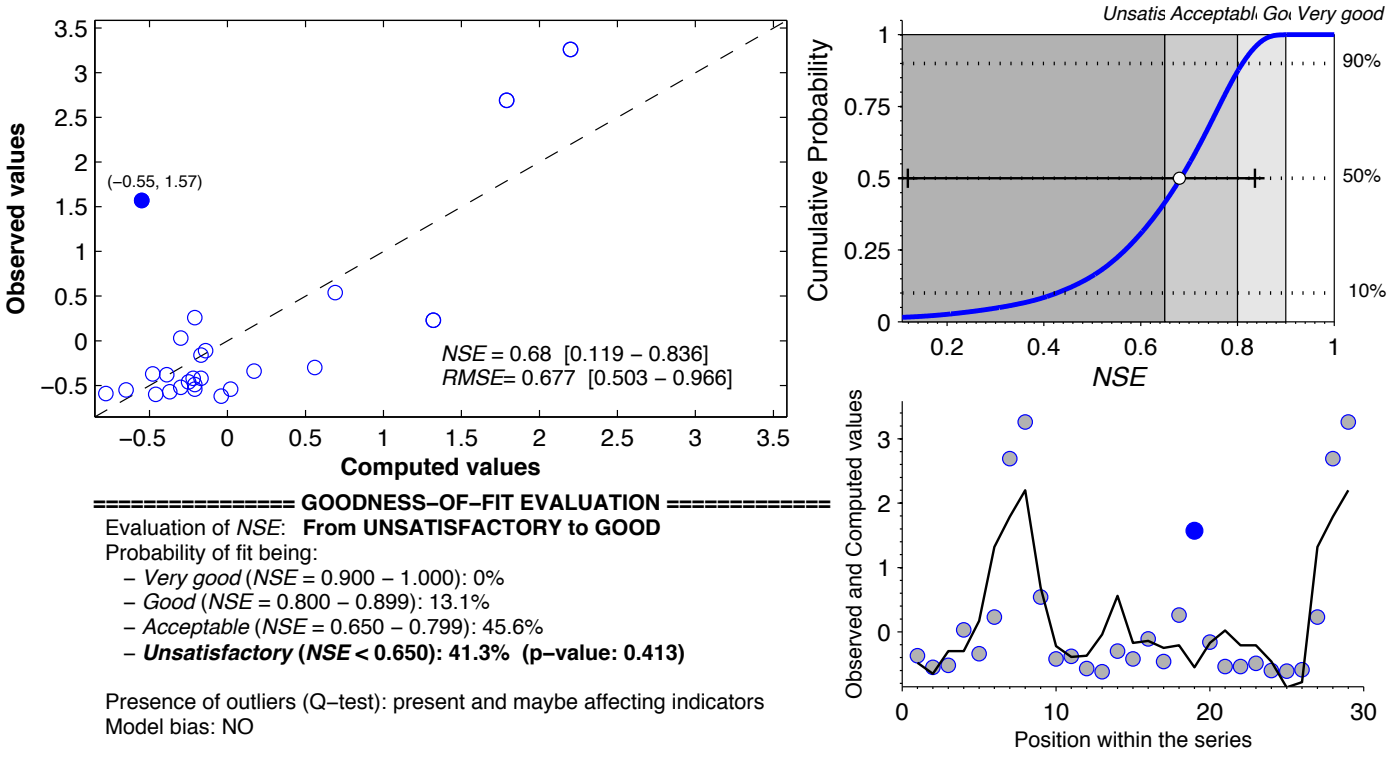


Figure 3. Graphical output of the new FITEVAL tool for model goodness-of-fit assessment.

UZIG welcomes newly elected 2015 - 2016 Chair

By Amanda Garcia and Wes Henson
USGS Hydrologists

The newsletter committee would like to welcome the newly elected 2015 - 2016 UZIG Chair, Jared Trost. The UZIG steering committee unanimously elected Jared in December 2014. Jared is a hydrologist with the USGS Minnesota Water Science Center and Toxics Site Manager for the National Crude Oil Spill Research Site in Bemidji.

Jared was first exposed to the UZIG in 2007 when he attended the Los Alamos meeting with coworker Geoff Delin. "It was a fantastic opportunity to connect people with published science," said Jared. When then current UZIG Chair John Nimmo asked for assistance with UZIG tasks such as membership management, Jared gladly stepped forward. "Perhaps it was John's inspiring request, perhaps it was the entire desert science experience, but I was moved to volunteer," replied Jared.

Jared has since worked to "create a digital, accessible presence for UZIG" by leading the Membership working group and actively participating in the Website working group.

"Efficient communication is fundamental to the sciences," said Jared. "There are many good ideas and good people that simply need to be connected to get a project moving forward. Nearly 30 new members joined UZIG through the web page, many from overseas. Now that UZIG-L is live (with over 440 members), I look forward to great digital discussions among unsaturated zone scientists."

Jared Trost analyzing soil gas samples on a GC. Photo from *Isanti County News*, March 1, 2015.

Farewell and thank you to outgoing UZIG Chair Randy Bayless

By Amanda Garcia and Wes Henson
USGS Hydrologists

The newsletter committee would like to thank Randy Bayless for honorably serving as the UZIG Chair over the last two years (2013-2014). As Chair of UZIG, Randy worked to strengthen and develop UZIG membership and recognition across the USGS, academia, and other Federal agencies. He also worked to encourage scientists to include the unsaturated zone in groundwater studies by promoting unsaturated zone expertise, equipment, and publications. Under his leadership we have revitalized the UZIG organization, increasing our visibility through our webinar series, biannual newsletter, and UZIG website. We now have the infrastructure in place to facilitate membership engagement and interaction through our comprehensive email list service. Even as Jared takes over leadership, Randy continues to be actively engaged in making UZIG a great resource for its membership. Randy is currently compiling an inventory of current unsaturated zone projects across the USGS and other UZIG affiliated agencies. This information will help keep our membership abreast of the latest methods and issues in unsaturated zone science. If you would like to contribute information about any unsaturated zone projects that you or other UZIG colleagues are working on, feel free to contact Randy (ebayless@usgs.gov).

Randy Bayless served as UZIG Chair from 2013 - 2014.

Letter from the incoming UZIG Chair

By Jared Trost
USGS Hydrologist
jtrost@usgs.gov

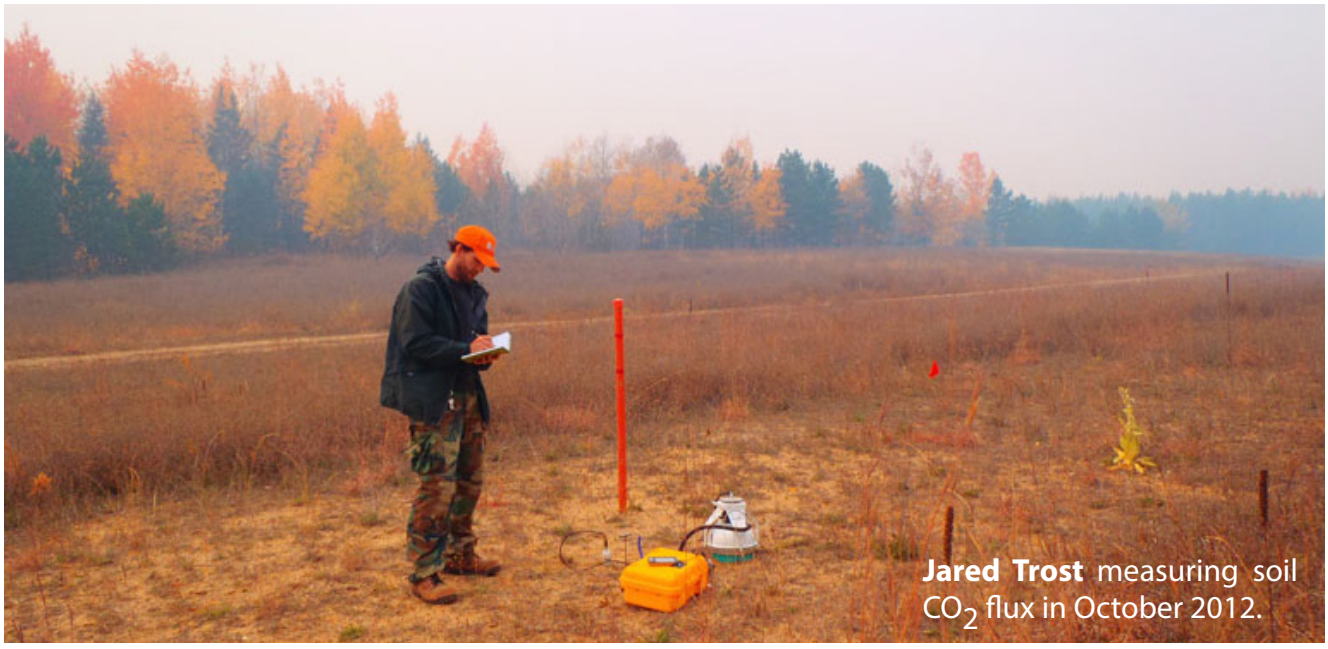
Thank you for the opportunity to serve as chair for the UZIG steering committee, I am honored. As the UZIG name implies, all members are connected by their interest and experience in the unsaturated zone—that veneer between the atmosphere and groundwater by which most of the human population is fed and upon which an abundance of life depends. Given the importance of the unsaturated zone, I am motivated by UZIG's mission to advance the science by fostering information exchange.

I recall the meeting organized by John Nimmo at the USGS National Groundwater Conference in Denver in 2012 that served as the spark to reignite UZIG. Following that meeting, a committed core of people put many ideas into action. I would like to thank Randy in particular for his excellent leadership of the steering committee over the past couple of years. He brought interesting discussion topics to the group and coordinated activities among productive subcommittees that resulted in many opportunities for interaction among unsaturated zone scientists including informal gatherings, topical sessions, field trips at conferences, webinars, and a regularly-updated web page.

Environmental sensing in the year 2015 can perhaps be compared to the digital technology revolution of the 1990's. Adequate digital infrastructure existed in the 1990s to enable people with ideas to gather and develop a new digital universe of information and communication. In the 2010s, new and cost-effective environmental sensing technologies, massive data storage and transfer capabilities, high speed computing capabilities, and burgeoning open-source programming communities are making data acquisition and analysis orders of magnitude faster and affordable

In this race to acquire and churn through massive data sets, a question of quality remains. I believe this highlights an important role for UZIG over the next couple of years. How can unsaturated-zone data be made more accessible? How should data be stored and made available on the web? What are standard measures of data quality that should accompany data? I believe that the scientists of UZIG can play an important role in addressing these questions.

In closing, UZIG "exists principally to promote informal, inter-disciplinary collaborations and sharing of ideas, expertise, and technical assets. Its mission is to advance unsaturated-zone science by fostering information exchange and collaborative studies among kindred groups across multiple organizations." I encourage you to be an active participant in the many mediums available through UZIG: webinars, UZIG-sponsored sessions at National Conferences, the newsletter, and the UZIG-L listserv. Please offer suggestions to the steering committee of new ways we can connect and interesting topics for discussion. I look forward to meeting many of you over the next few years.



Jared Trost measuring soil CO_2 flux in October 2012.

Letter from the outgoing UZIG Chair

By Randy Bayless
USGS Research Hydrologist
ebayless@usgs.gov

December 2014 marked the end of my 2-year term as UZIG Chair. Jared Trost was unanimously selected to serve as the next UZIG Chair and I am excited about the enthusiasm and technological ingenuity that he brings to his new role.

The UZIG Steering Committee has been very active during the last two years. Accomplishments include an enhanced website, a monthly webinar series, a biannual newsletter, an open-forum Listserv, and sponsored sessions and field trips at GSA and AGU. We hope that you will take advantage of these opportunities for networking and collaboration. If you would like to have a more active role in UZIG, please contact a member of the Steering Committee.

Regardless of the strides that we have made, we need to continue to push for recognition of UZIG in our agencies and amongst our peers, and to emphasize the importance of UZ studies in most hydrologic investigations. Technological advancements have erased many barriers that previously discouraged inclusion of UZ components in hydrologic investigations. State and nationwide soil-moisture networks, standardized quality-assurance methods and publically accessible real-time datasets are needed to simplify and legitimize UZ inclusion in more studies.

There are many exciting developments on the UZ horizon. An increasing number of simulation models include interesting provisions for UZ processes such as preferential flow, optimization and upscaling. The groundwater modeling standard, MODFLOW, now includes a module for simulating flow in the unsaturated zone. Disparate soil-moisture sensing networks are now being linked at singular web sites, and state and national networks are growing. Soon, surficial soil moisture will be globally available every 2-3 days through the NASA SMAP satellite.

I encourage you to be an active UZIG member by providing feedback to the Steering Committee, attending the monthly UZIG webinars, submitting papers for the UZIG-sponsored sessions at National Conferences, sharing your research through the newsletter, and communicating through the UZIG Listserve. The perceived complexity of the unsaturated zone can sometimes isolate UZ scientists; UZIG is one way to realize that there is a huge international interest in UZ studies and more importantly in the work that you are doing.

Thank you for the opportunity to serve-
Randy

Featured Publications

By Andy O'Reilly
University of Mississippi
aoreilly@olemiss.edu

"Featured Publications" highlights recently published work (for example, an article, book, or technical report) of UZIG members. The guidelines for listing of a publication are as follows:

- At least one of the authors or coauthors must be a UZIG member
- Publication must have been published in the last year
- Content must be directly related to unsaturated-zone research topics
- Only the publication citation is listed (no reviews or other comments)
- Citations are listed in alphabetical order by first author's last name

Please email Andy O'Reilly (aoreillly@olemiss.edu) any citations for your work meeting these criteria that you would like to be included in an upcoming newsletter.

Book Review:

Stonestrom, D.A., 2014, Terrestrial Biosphere-Atmosphere Fluxes and Transport in the Atmosphere-Vegetation-Soil Continuum: Groundwater, v. 52, no. 6, p. 821-822, doi:10.1111/gwat.12270 [http://dx.doi.org/10.1111/gwat.12270].

UZIG web seminar series - upcoming presentations

By Mindy Erickson
USGS Hydrologist
merickso@usgs.gov

In September 2013, USGS began hosting a bi-monthly UZIG web-based seminar series (webinar). Recent webinars included David Stonestrom, USGS, who presented "Thirty-eight years of desert unsaturated-zone research: What have we learned at the USGS Amargosa Desert Research Site?" and Daniella Rempe, Berkeley, who presented "Rock moisture dynamics in the Eel River CZO: Field observations of unsaturated moisture storage in weathered, fractured bedrock under steep hillslopes." Ramon Naranjo, USGS, presented "Using heat as a tracer to quantify seepage losses from agricultural canals in the Walker River Basin, Nevada" on March 27.

May

Date May 15, 2015 Noon Central Time (17:00 UT)

"Minnehaha Creek, Minnesota; Sources for base-flow and causes for losing reaches."

Professor John Nieber, University of Minnesota

September

Date TBD, Sept. 2015 Noon Central Time (17:00 UT)

Infiltration In Hawaiian Soils: An Evaluation of Vegetation Influences

Kim Perkins, USGS

November

Date TBD, Nov. 2015 Noon Central Time (17:00 UT)

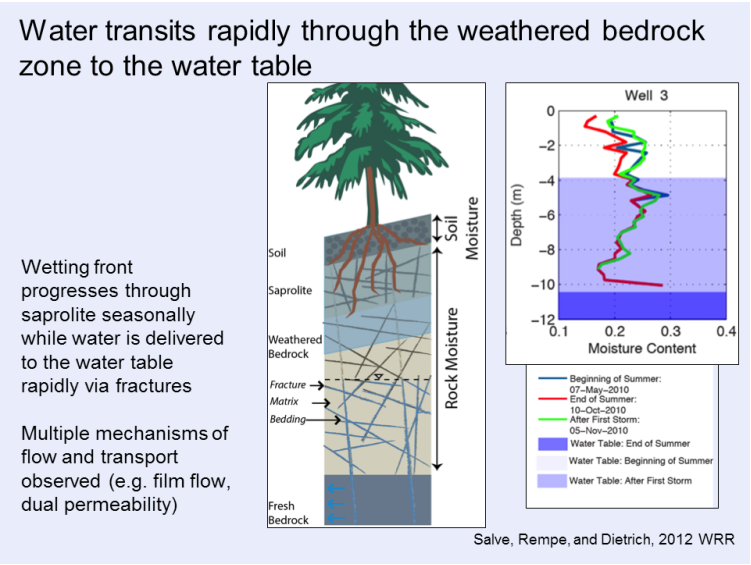
"How to choose solution methods for saturation-dependent flow and transport problems: Critical-path analysis, percolation scaling, or effective-medium formulations?"

Allen Hunt, Wright State University
Department of Earth & Environmental Sciences

The webinar series provides an easily-accessible (and virtually free) forum for UZIG members to introduce themselves to one another and to share their research results. While conference attendance is more challenging than in the past, the series provides a way to keep in touch and keep up with current research, and a way to build and maintain the personal connections that are crucial for building collaborations. Past webinar information is archived on the webinar series web page.

UZIG webinars will be advertised via email announcement prior to each talk. The UZIG webinar series is being coordinated by Minnesota Water Science Center hydrologist and groundwater specialist Mindy Erickson (merickso@usgs.gov). If you would like to present your work at an upcoming webinar – or to suggest someone else as a possible webinar presenter – please contact Mindy. A webinar schedule with presenter and topic information (including past presentation information) is provided on the UZIG web page.

Please mark your calendars for these upcoming UZIG webinars – we look forward to 'seeing' you!



Highlight from the January 2015 webinar: Illustration of flow processes below the root zone from Daniella Rempe's presentation.

Active UZ projects and collaboration opportunities

By Randy Bayless
USGS Research Hydrologist
ebayless@usgs.gov

An initiative was announced in the Fall 2014 newsletter to compile and maintain a list of UZ projects where UZIG members are actively researching. The list includes the general goals of the project, the site conditions, the techniques and methods being applied, and publications related to the project. The purpose for the list is to enhance collaborative and information-sharing opportunities between UZ scientists.

An example of some of the information that will be shared in the compilation is shown in the table below. The completed compilation containing much more information will be posted to the UZIG website. Projects in the compilation may be lab, field, and/or modeling oriented. If you have an active project that you would like to have included in the compilation, please contact Randy Bayless (ebayless@usgs.gov).

Point of Contact	Site Name	Collaborators	Setting	Goals
Thomas Harter (University of California, Davis)	Kearney Research Site	Jan Hopmans (UC Davis), Willi Horwath (UC Davis), Sanjai Parikh (UC Davis), Kate Scow (UC Davis), Alex Furman (UC Davis)	Orchard (Irrigated)	1. Characterize and understand nitrate transport and fate, especially the in deep UZ. 2. Develop and validate appropriate modeling tools.
Roy Bartholomay (USGS-Idaho)	Idaho National Laboratory	John Nimmo (USGS), Kim Perkins (USGS), Brittany Johnson (USGS), Kaitlyn Creasy (USGS), Ben Mirus (Univ. North Carolina)	Low-level waste respository	1. Measure UZ hydraulic properties. 2. Evaluate property transfer models. 3. Test methods to parameterize a preferential-flow model.
Jeff Kennedy (USGS-Arizona)	Southern Avra Valley Storage and Recovery Project	Ty Ferre (Univ. Arizona)	Artificial recharge basins	1. Demonstrate the value of gravity measurements to monitor infiltration.

Humor Corner

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